Real World Interoperability
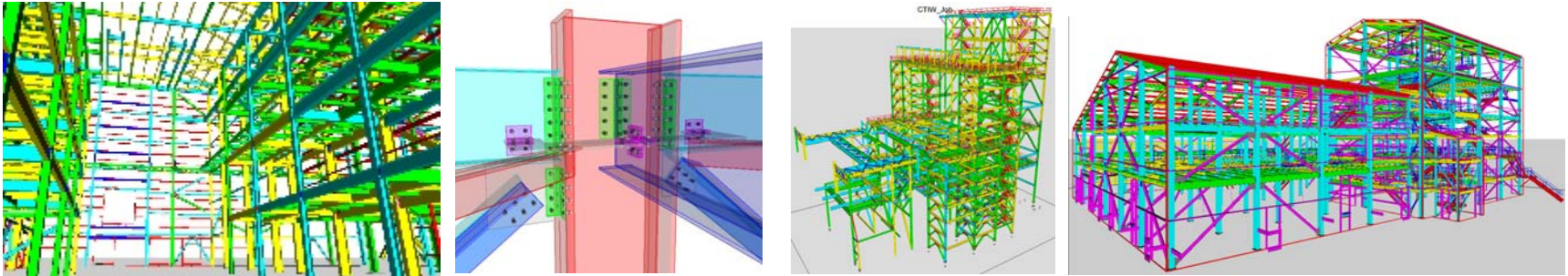
Robert Lipman

National Institute of Standards and Technology (NIST)

Building and Fire Research Laboratory

Computer Integrated Building Processes Group

Gaithersburg, Maryland

cis2.nist.gov

Design Data Interoperability Network – 15 October 2008

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Outline

- NIST Overview
- CIS/2 – CIMsteel Integration Standards
- IFC – Industry Foundation Classes
- Interaction between CIS/2, IFC
- NIST Reseach - Certification
- Precast Concrete
- BIM

- Disclaimer: Any mention of commercial products in this presentation is for information only; it does not imply recommendation or endorsement by NIST.

NIST At A Glance

Gaithersburg, MD

Boulder, CO

- NIST Research Laboratories
- Baldrige National Quality Award
- Manufacturing Extension Partnership
- Technology Innovation Program

- ~ 2,800 employees
- ~ 2,600 associates and facility users
- ~ 1,600 field staff in partner organizations
- ~ 400 NIST staff serving on 1,000 national and international standards committees
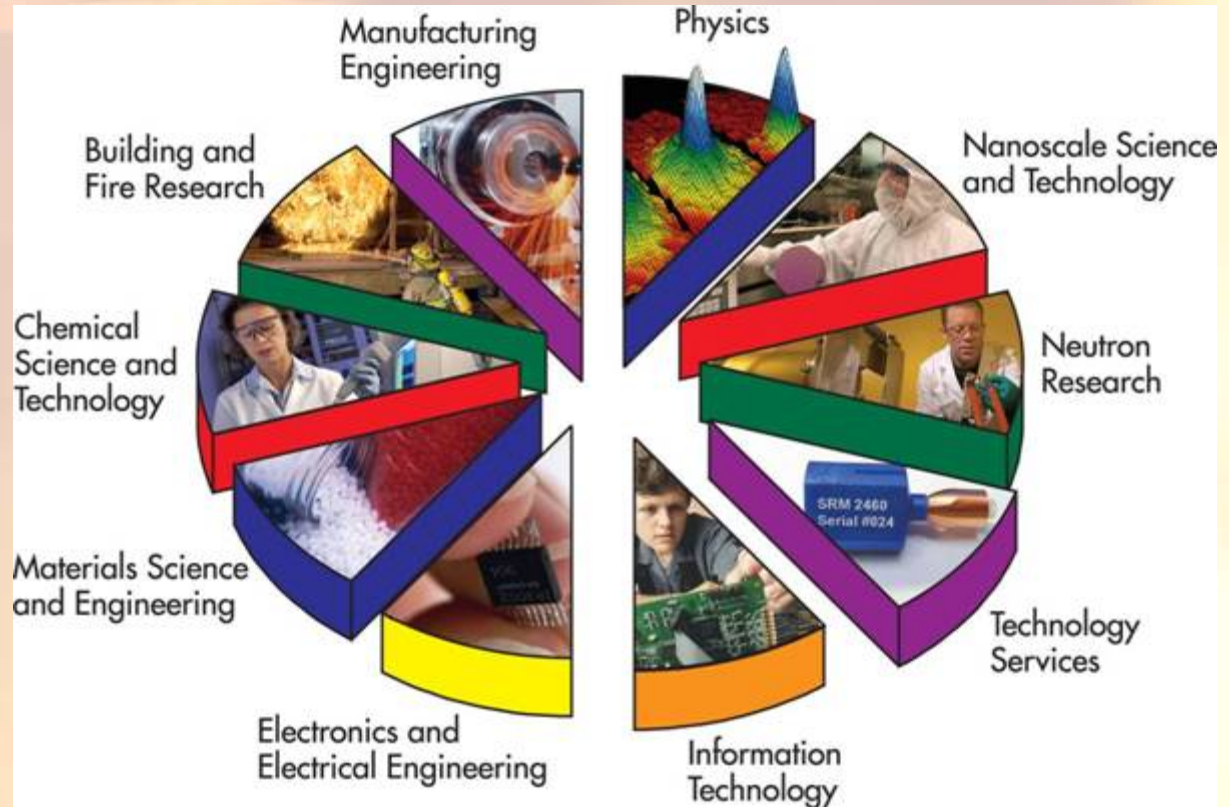
BFRL

The NIST Laboratories

NIST's work enables

- **Advancing manufacturing and services**

- **Helping ensure fair trade**

- **Improving public safety and security**

- **Improving quality of life**

NIST works with

- **Industry**

- **Academia**

- **Other agencies**

- **Government agencies**

- **Measurement laboratories**

- **Standards organizations**

BFRL

What is the Problem?

- 40 year *decline in construction productivity* (-0.6% per year)
  - contrast to *increase* in productivity of non-farm industries (+1.8% per year)

- 25-50% w**aste and inefficiencies** in labor and material control

- **$17-36 B/yr cost of** *inadequate interoperability*

- Facing projected $2 trillion cost-burden for infrastructure renewal

- Increasing competition from other nations
  - Chinese contractors: 160% increase in contracts in US and Europe in 2007

- **Measurement science is lacking** to measure impact of inefficient construction or new technologies:
  - to determine productivity at discrete and aggregate levels
  - **to enable automated access and integration of diverse information systems**
  - to enable real-time monitoring and control of construction
  - to enable automation and integration of construction processes

BFRL
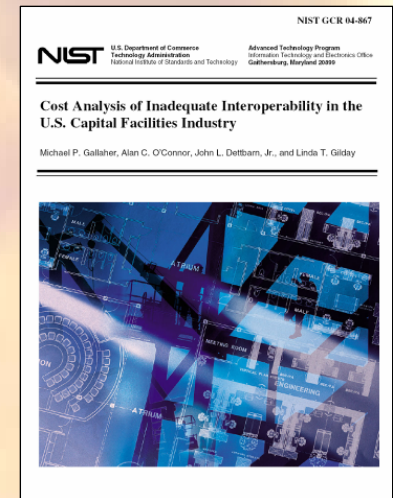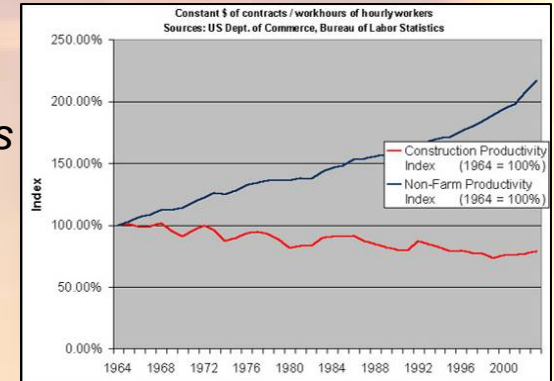
Project Portfolio

- **Methods and Metrics for Conformance Testing of Construction Project Data Standards**
- Virtual Project Data Integration Testbed
- Construction Control Using 3D Imaging and Building Information Models

- Performance and Use of 3D Imaging Systems
- Construction Object Recognition and Tracking
- Intelligent and Automated Construction Job Site Research Testbed

- Metrics and Tools for Construction Productivity

- Standards for Building Information Exchange with First Responders

BFRL

A Case for Neutral Product Models and Interoperability
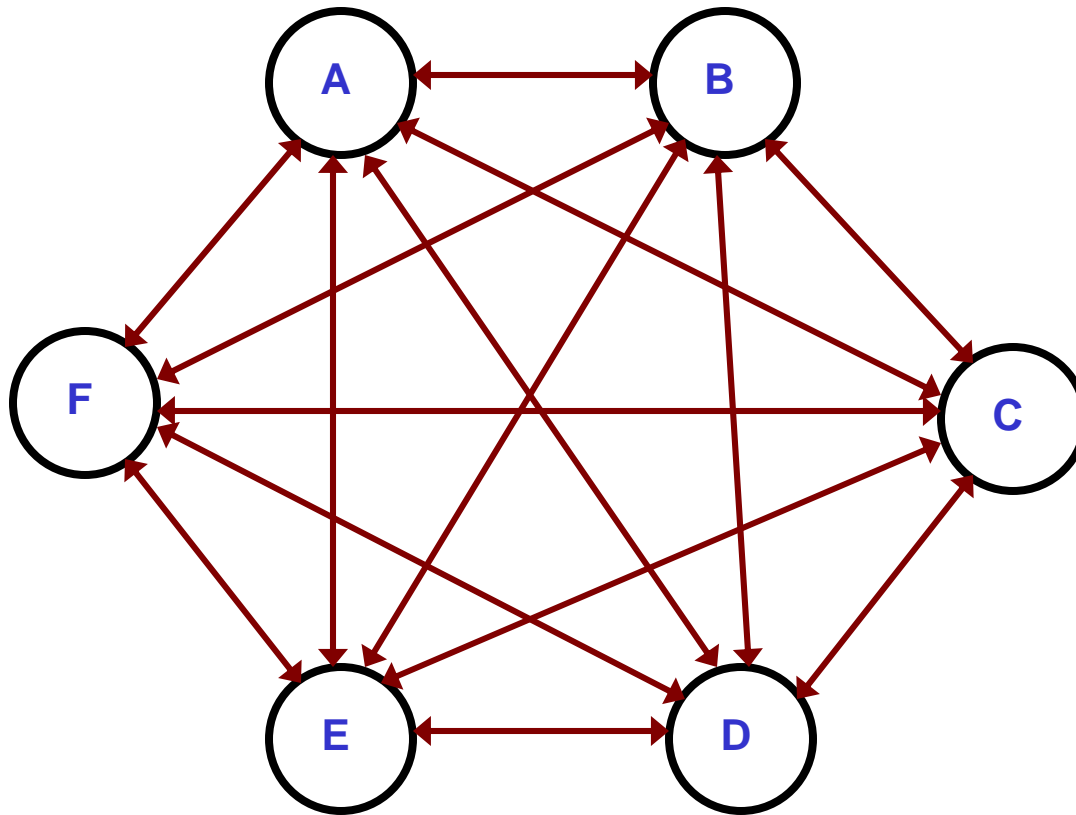
- 6 software packages

- Each has their own proprietary format

- Import and export

- N*(N-1) translators

- 30 import/export translators (N=6)

- Adding another software package is 12 translators (N=7)

A Case for Neutral Product Models and Interoperability
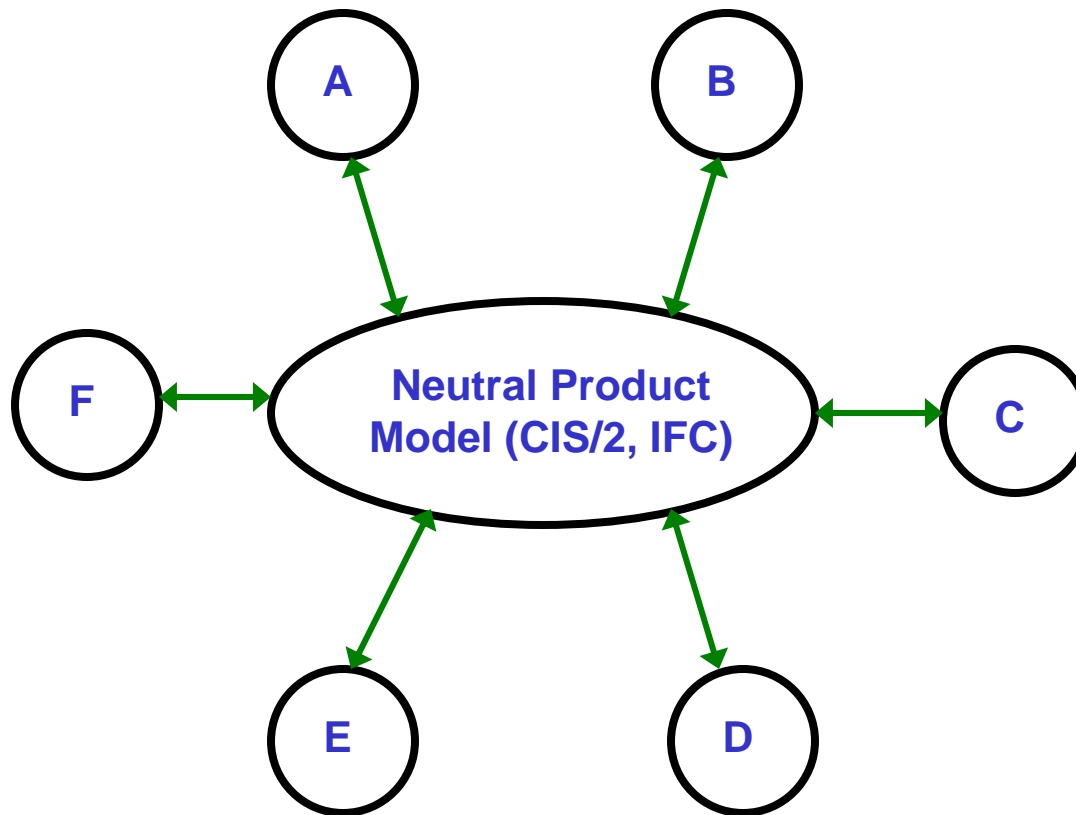
- 6 software packages

- Translate to neutral product model

- Import and export

- 2*N translators

- 12 translators

- Adding another software package is only 2 translators

Interoperability In Reality
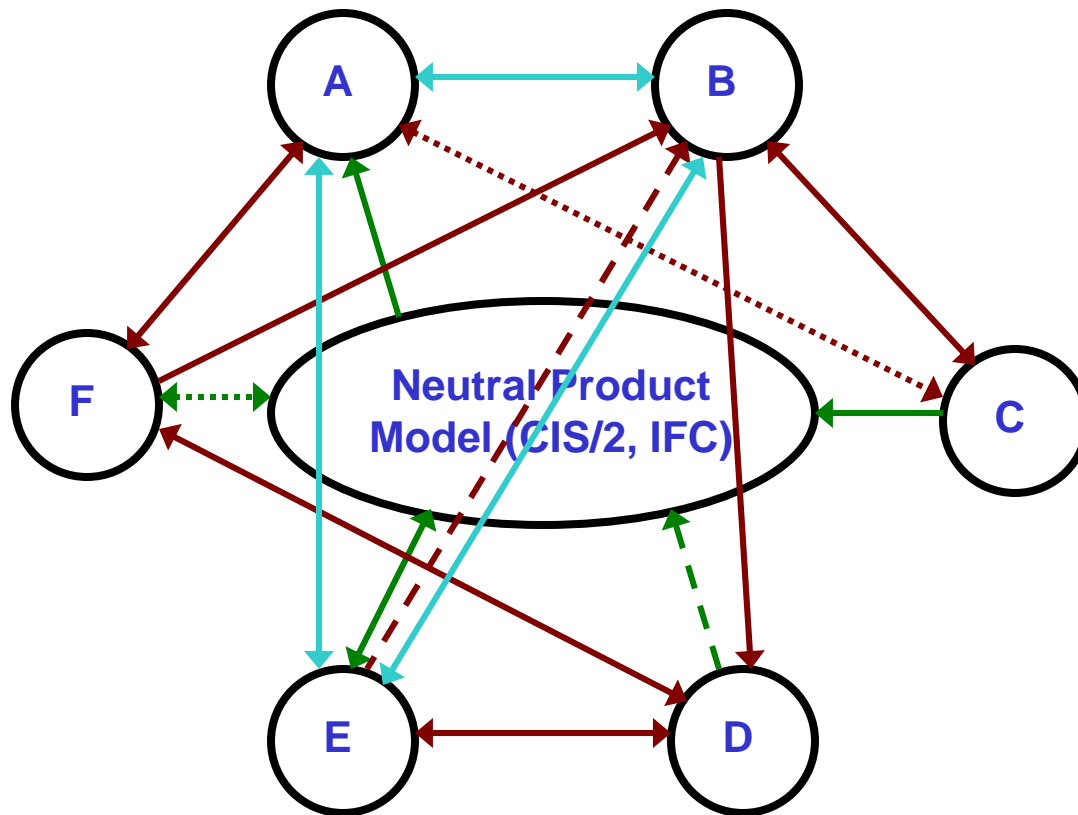
- Old formats survive (KISS, SDNF)

- Import OR export

- Incomplete implementations

- Geometry vs. objects

- Incomplete product model

- Software APIs

- Strategic alliances

- Software consolidation
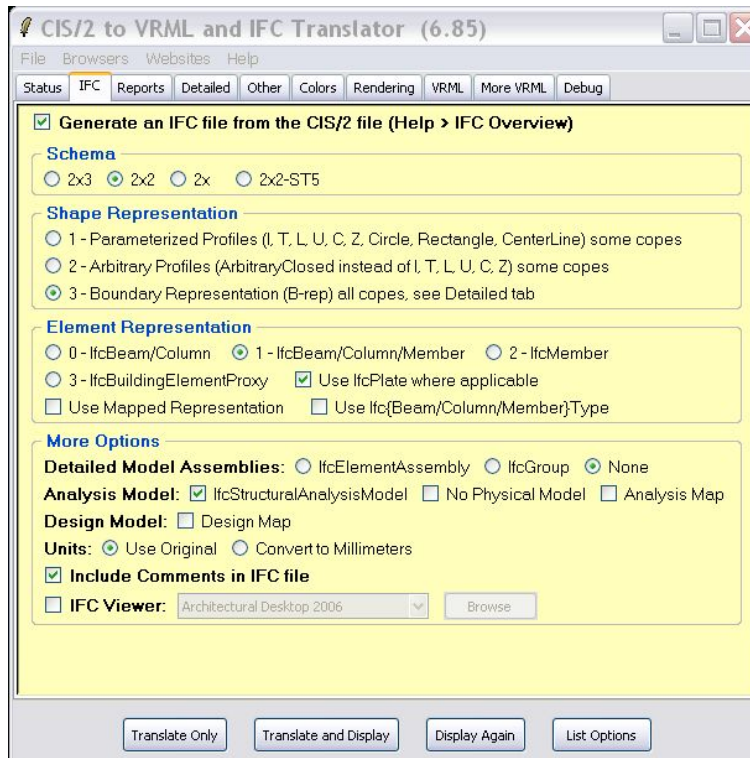
- Vendor specific information

What is CIS/2?

- CIMsteel Integration Standards
- Developed by Andrew Crowley and Alastair Watson at the Steel Construction Institute (UK)
- Adopted by AISC in 1998
- NIST participated in the review team that chose CIS/2

- Design, Analysis, and Detailed models (views) of a structure
- Logical relationship between models
- Parts, assemblies, loads, reactions, materials, connections, …

- 15+ implementations import and/or export
- Has been very successful, at the forefront of interoperability
- Well defined domain, workflows, implementations
- Parts of the CIS/2 specification have never been implemented
- Room for improvement

SteelVis - CIS/2 to VRML Translator

- VRML – Virtual Reality Modeling Language, 3D in a web browser, freely available plugins
- Started development of SteelVis - CIS/2 to VRML Translator in 2000
- NASCC - 2001, Online web interface - 2001, Windows – 2003
- Only CIS/2 viewer available

- Software developers use it to verify their CIS/2 export
- End users use it for design review, model sharing, electronic RFI, marketing, BOM, …

- Thoroughly tested with many CIS/2 files
- Over 2000 downloads, 100s of upgrades from older versions
- Current Version 7.80
- Integration with 3D PDF, Google Earth, Google SketchUp

SteelVis user interface

VRML model

IFC model

Part summary

CIS/2 to VRML and IFC Translator (6.85)

File   Browsers   Websites   Help

Status | IFC | Reports | Detailed | Other | Colors | Rendering | VRML | More VRML | Debug

☑ Generate an IFC file from the CIS/2 file (Help > IFC Overview)

Schema
○ 2x3 ◉ 2x2 ○ 2x   ○ 2x2-ST5

Shape Representation
○ 1 - Parameterized Profiles (I, T, L, U, C, Z, Circle, Rectangle, CenterLine) some copes
○ 2 - Arbitrary Profiles (ArbitraryClosed instead of I, T, L, U, C, Z) some copes
◉ 3 - Boundary Representation (B-rep) all copes, see Detailed tab

Element Representation
○ 0 - IfcBeam/Column   ◉ 1 - IfcBeam/Column/Member   ○ 2 - IfcMember
○ 3 - IfcBuildingElementProxy   ☑ Use IfcPlate where applicable
☐ Use Mapped Representation   ☐ Use Ifc{Beam/Column/Member}Type

More Options
Detailed Model Assemblies: ○ IfcElementAssembly ○ IfcGroup ◉ None
Analysis Model: ☑ IfcStructuralAnalysisModel ☐ No Physical Model ☐ Analysis Map
Design Model: ☐ Design Map
Units: ◉ Use Original ○ Convert to Millimeters
☑ Include Comments in IFC file
☐ IFC Viewer: [Architectural Desktop 2006] [Browse]

[Translate Only]   [Translate and Display]   [Display Again]   [List Options]

DesignData3_ctv.wrl (model/vrml Object) - Mozilla Firefox

File   Edit   View   Go   Bookmarks   Tools   Help

DesignData3_ctv.wrl (model/vr...

Front

Done

Autodesk Architectural Desktop 2006 - [Drawing1.dwg]

File   Edit   View   Insert   Format   Window   IFC-Utility   Help

Model / Work

Scale: 1/8" = 1'-0" ▼   Medium Detail ▼

Command: '_help

CIS/2 Summary Report - SDS/2 Training Seminar Model (JS) - Mozil...

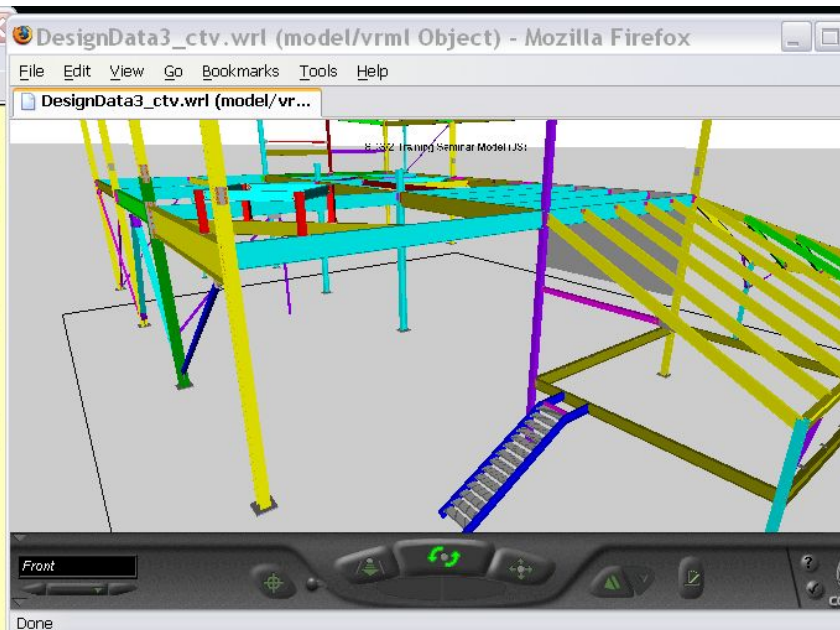File   Edit   View   Go   Bookmarks   Tools   Help

CIS/2 Summary Report - SDS/2 ...
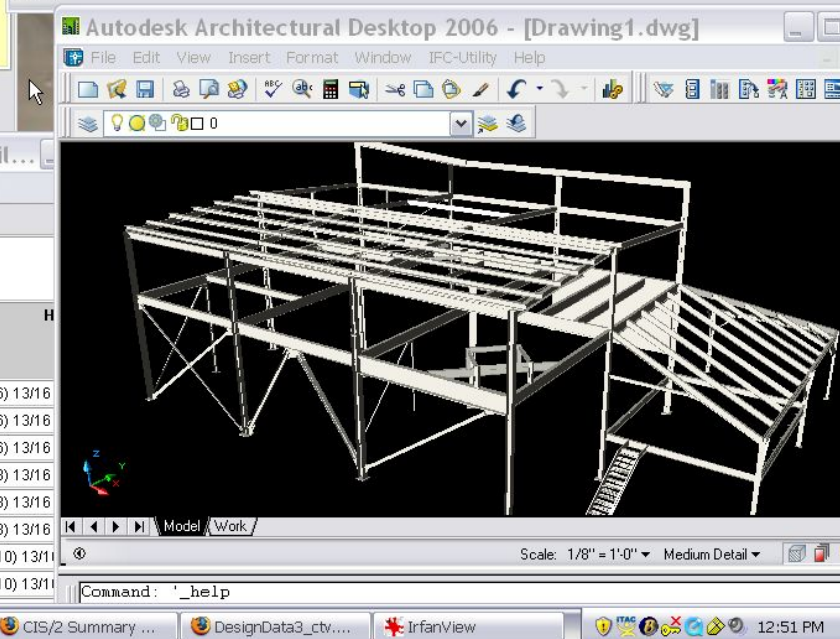
2003-11-15 08:40:40-06:00
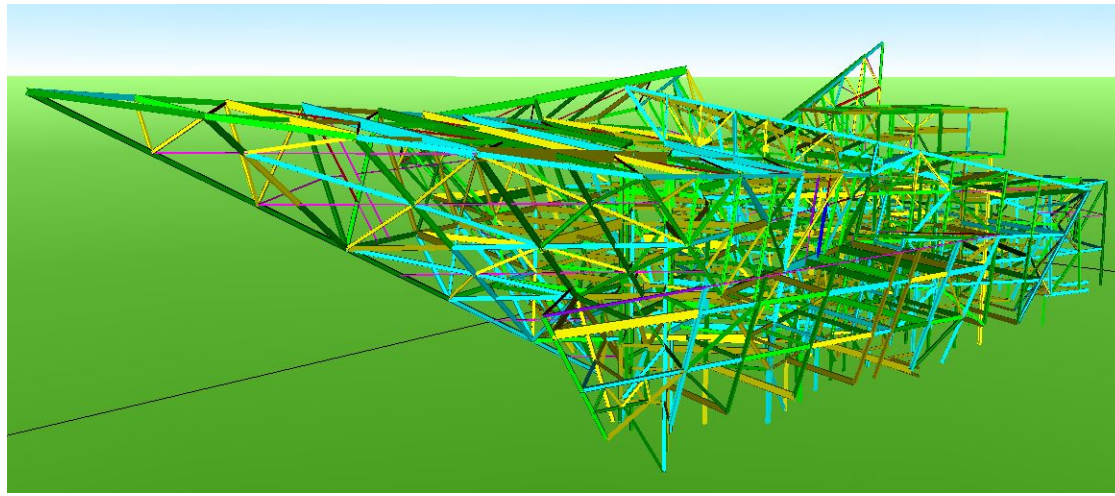
Part List (Material List, Assembly List, Bolt List)

	Qty	Mark (Bold-main)	Size (Link to Material List)	Length (Ft-In)	Grade	Unit Wgt* (Lbs)	Total Wgt* (Lbs)	Function	H
1	36	a1	L4x3-1/2x5/16	8 1/2	A36	5.4	195	Beam	(6) 13/16
2	6	a2	L3-1/2x3x5/16	0-10	A36	5.5	33	Beam	(6) 13/16
3	6	a3	L3-1/2x3x5/16	0-10	A36	5.5	33	Beam	(6) 13/16
4	3	a4	L3-1/2x3x5/16	1-1	A36	7.2	22	Beam	(8) 13/16
5	3	a5	L3-1/2x3x5/16	1-1	A36	7.2	22	Beam	(8) 13/16
6	24	a6	L4x3-1/2x5/16	11 1/2	A36	7.3	176	Beam	(8) 13/16
7	5	a7	L3-1/2x3x5/16	1-4	A36	8.9	44	Beam	(10) 13/16
8	5	a8	L3-1/2x3x5/16	1-4	A36	8.9	44	Beam	(10) 13/16

🏁 start   CIS/2 to VRML a...   Autodesk Archite...   CIS/2 Summary ...   DesignData3_ctv...   IrfanView   12:51 PM

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Denver Art Museum
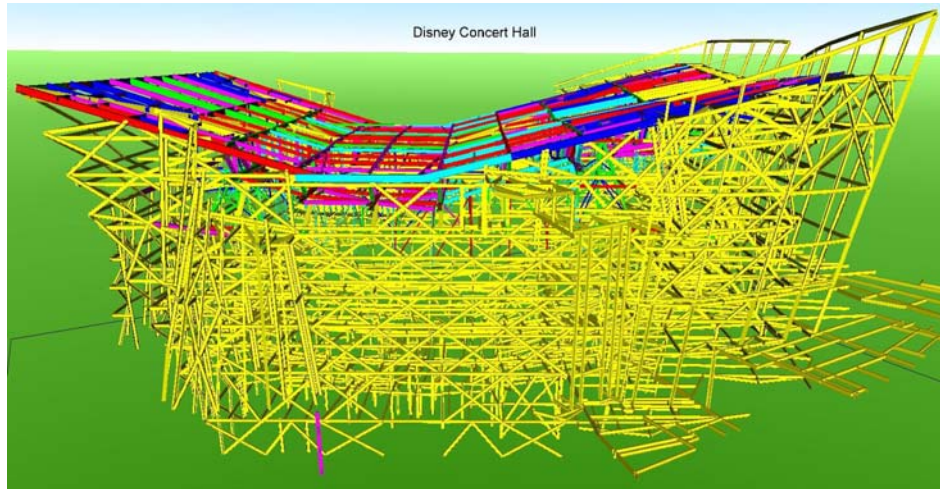
Disney Concert Hall
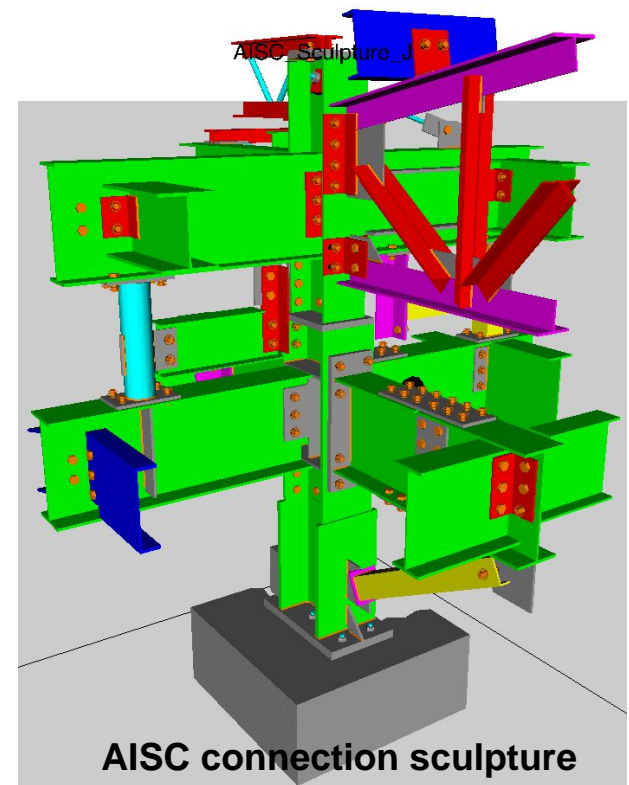
AISC_Sculpture_J

AISC connection sculpture

VRML from CIS/2 files

NIST
National Institute of Standards and Technology
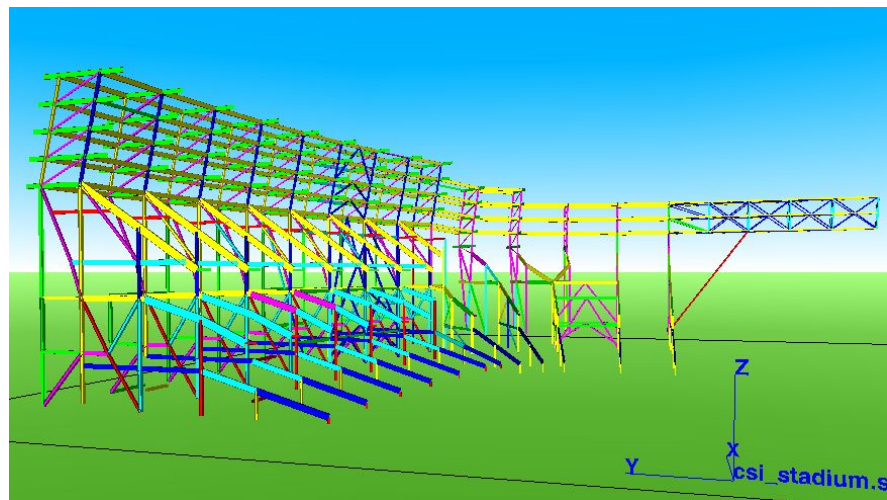Technology Administration, U.S. Department of Commerce

BUILDING AND FIRE RESEARCH LABORATORY
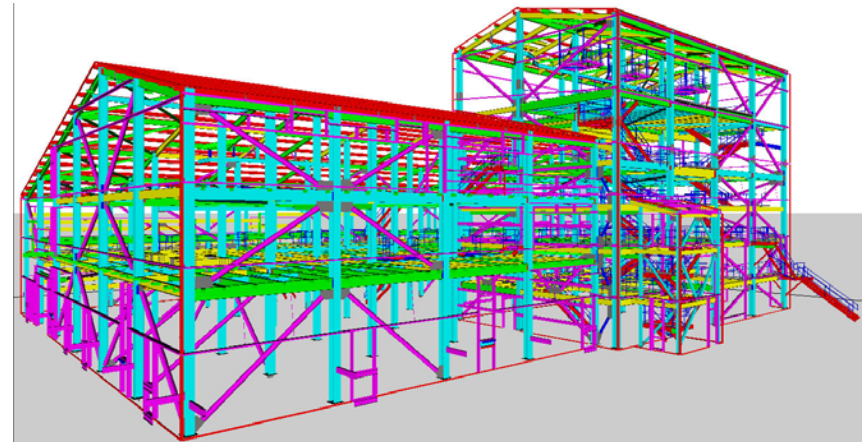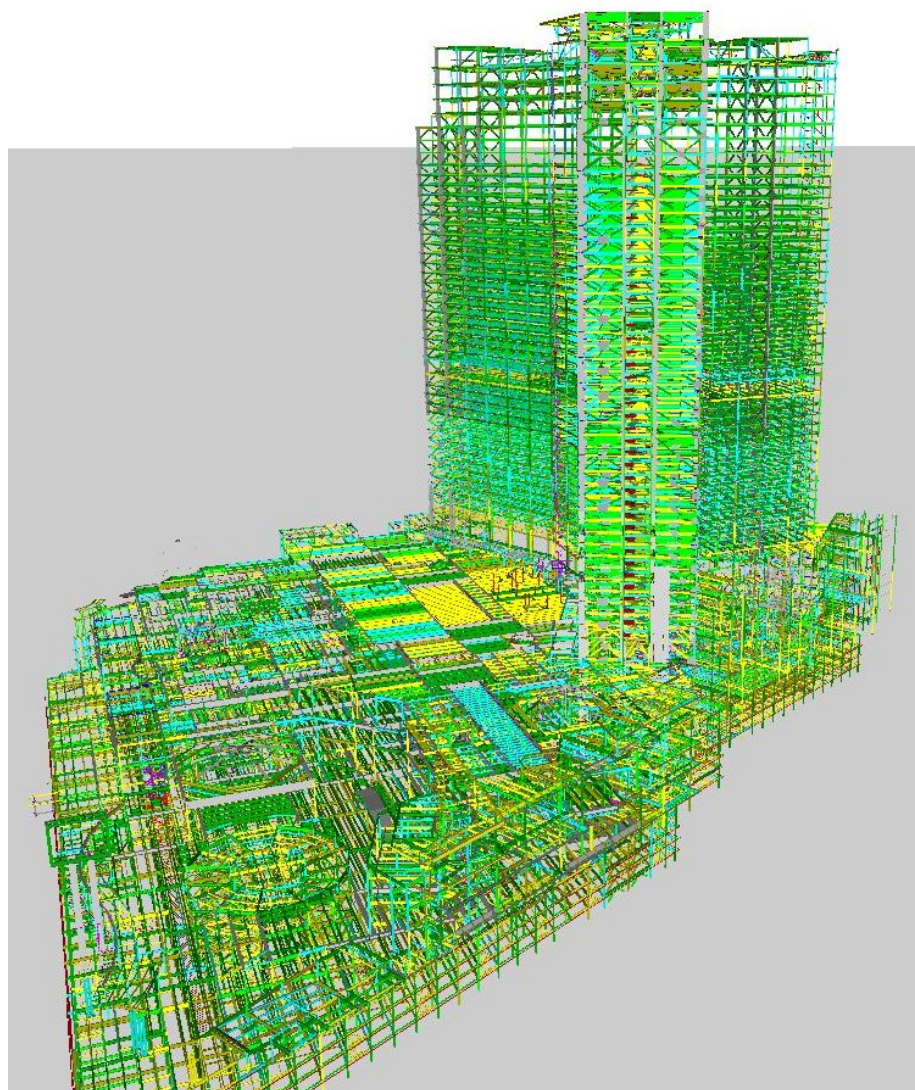
GOLDEN GATE BRIDGE - 3D MODEL: MASS-NO BOT. ORTHO. DECK(1965)

Golden Gate Bridge

Soldier Field
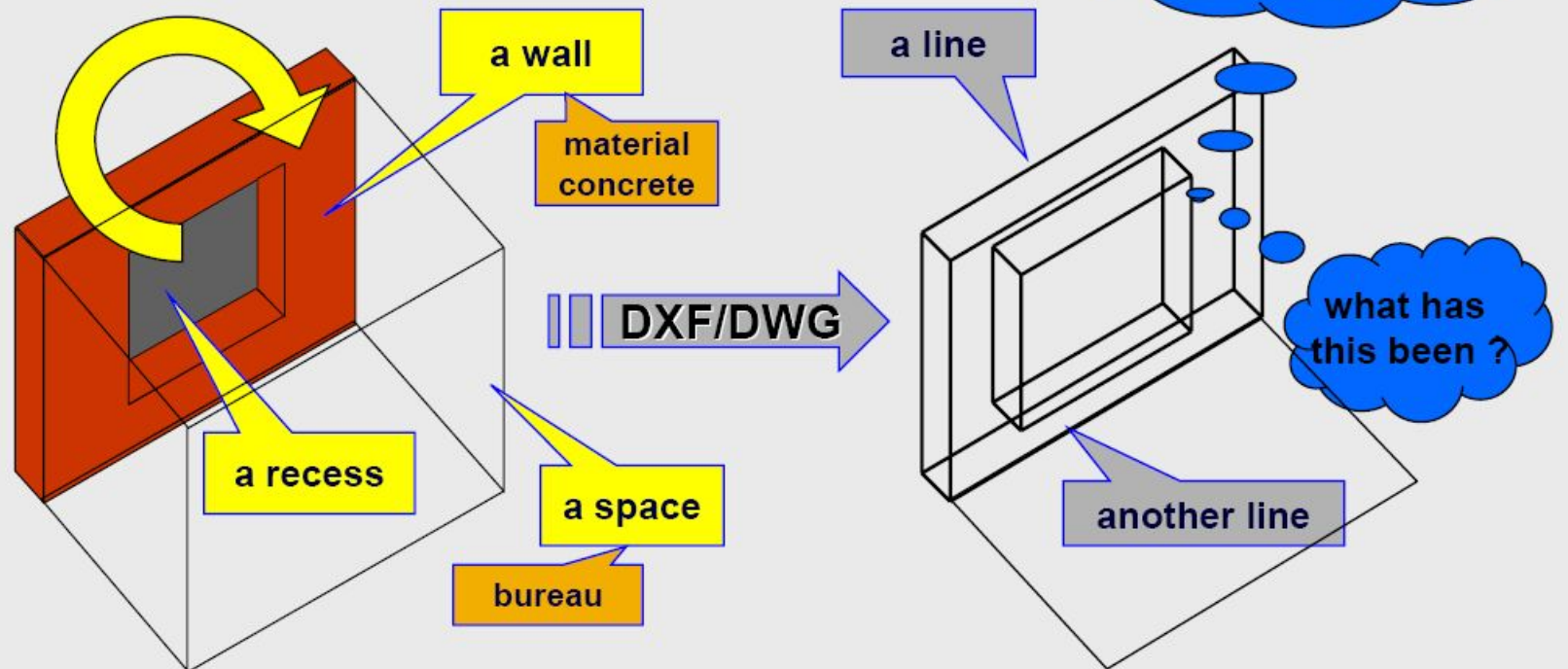
Las Vegas hotel – 6 CIS/2 files – 230,503 parts

What is IFC?

- Industry Foundation Classes (IFC) are the product data model to facilitate interoperability in the building industry
- Developed by the IAI (International Alliance for Interoperability), now known as buildingSMART

- Building information not geometry
- Design, analysis, HVAC, facilities management, operations, quantity takeoff, energy simulation, code checking, cost estimating …
- Well defined architecture and domain extension mechanism
- Model views being developed based on business process and exchange requirements (IDM), define what needs to be implemented in software (MVD)

- Implemented by most of the major CAD applications, many downstream applications
- Many free IFC viewers, file browsers, and syntax checkers
- Current version IFC2x3
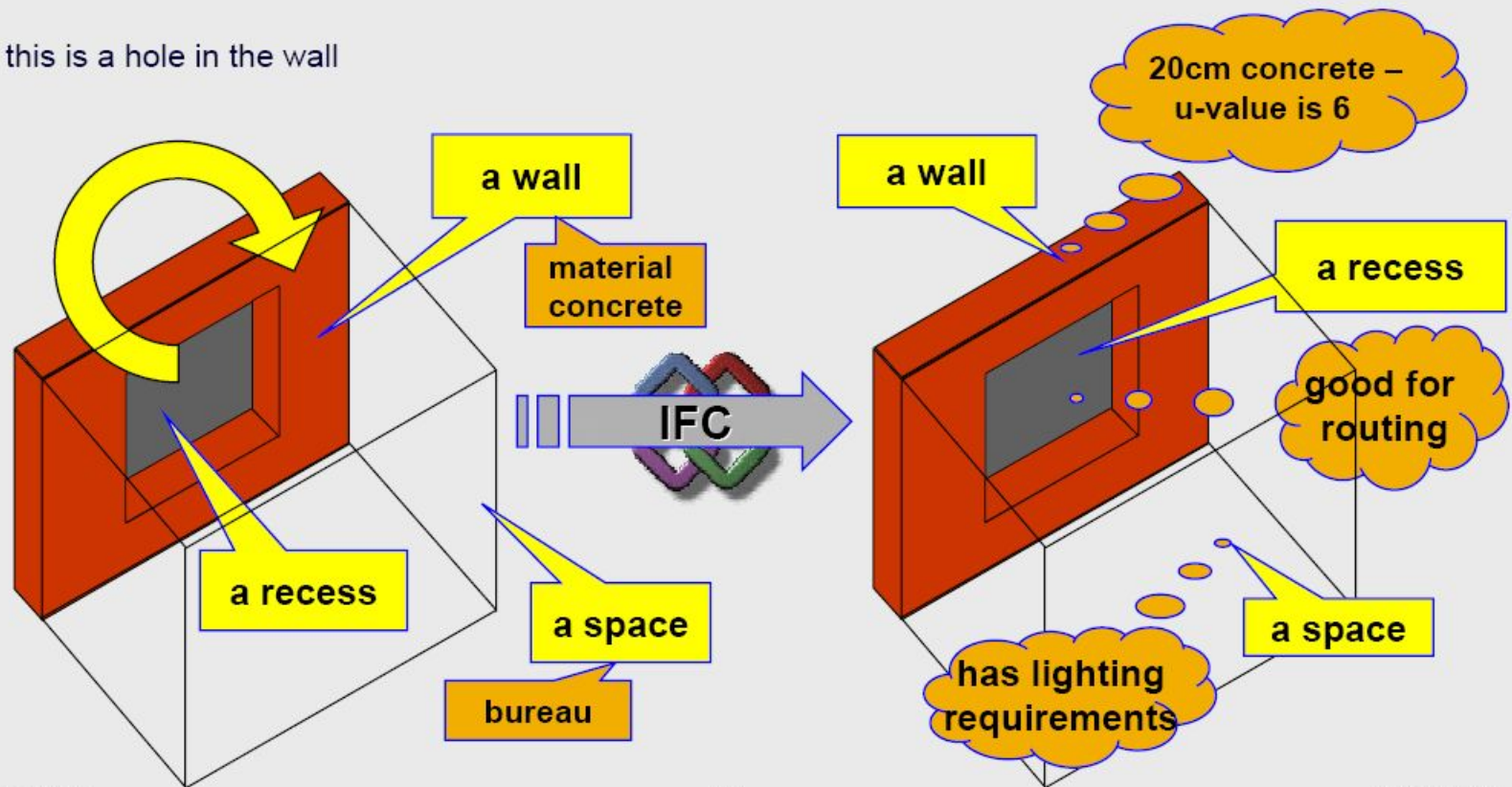
Why is IFC a solution ?

AEC3

▸ **all intelligent object information are exchanged, they can be reused and interpreted in other applications throughout the life cycle**
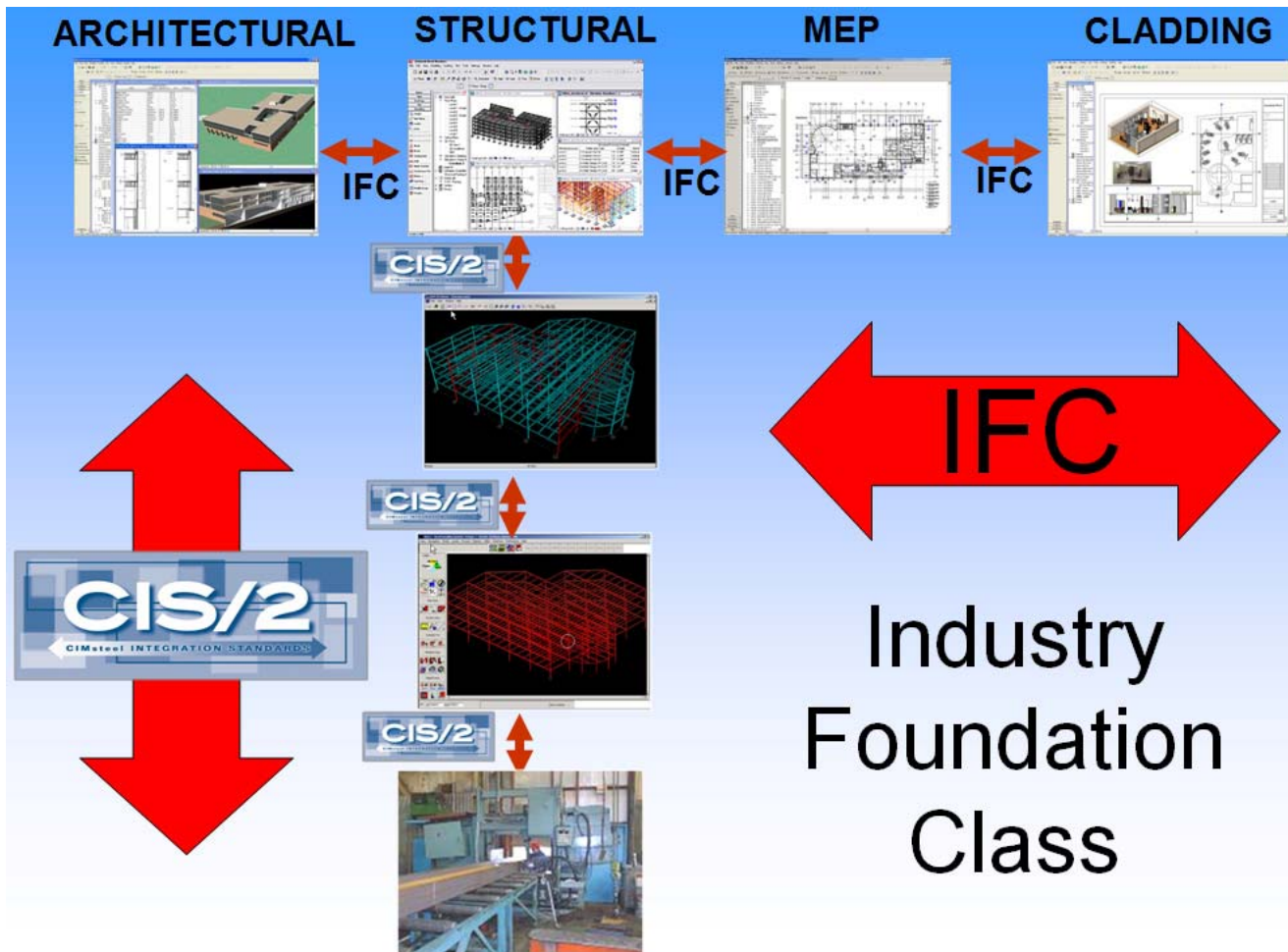
this is a hole in the wall

20cm concrete – u-value is 6

a wall

material concrete

a wall

IFC

a recess

good for routing

a recess

a space

bureau

a space

has lighting requirements

Interaction Between CIS/2 and IFC

Interaction Between CIS/2 and IFC

- Developed mapping between CIS/2 and IFC
- One-to-one, one-to-many
- Implemented as CIS/2 to IFC translator in 2005 as part of SteelVis
- Identified deficiencies in IFC to handle structural steel, contributing to future versions of IFC
- Some of the deficiencies include: bolts, holes, welds, copes, parametric profiles, attributes (section designator, piecemark, cardinal point), semantic meaning
- End users moving CIS/2 models into IFC applications, for example RAM and SDS/2 to Revit and ArchiCAD
- IFC to CIS/2 mapping

- **Will IFC replace CIS/2?**

Interaction Between CIS/2 and IFC

- Developed mapping between CIS/2 and IFC
- One-to-one, one-to-many
- Implemented as CIS/2 to IFC translator in 2005 as part of SteelVis
- Identified deficiencies in IFC to handle structural steel, contributing to future versions of IFC
- Some of the deficiencies include: bolts, holes, welds, copes, parametric profiles, attributes (section designator, piecemark, cardinal point), semantic meaning
- End users moving CIS/2 models into IFC applications, for example RAM and SDS/2 to Revit and ArchiCAD
- IFC to CIS/2 mapping

- **Will IFC replace CIS/2?**
- **No** – CIS/2 is very good at what it does, IFC might get better for steel, but won't equal what CIS/2 can do
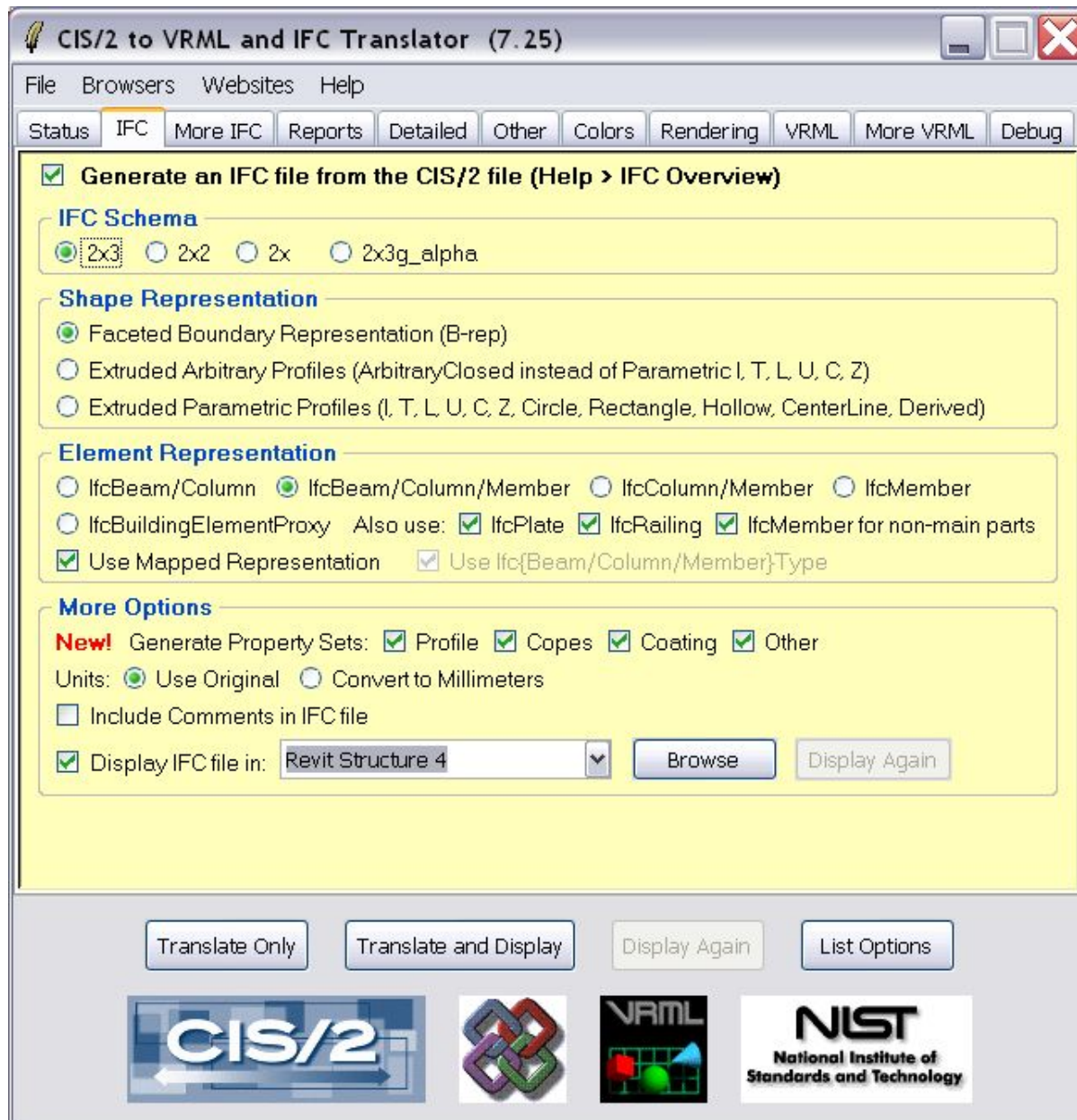
IFC options in the translator

< IFC schemas

< shape representations

< element representations

< property sets

< display in IFC applications

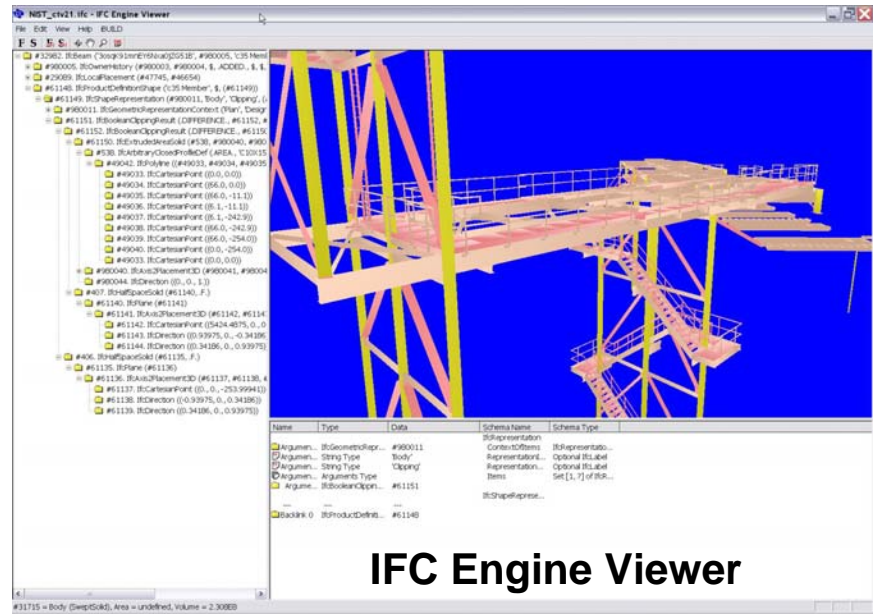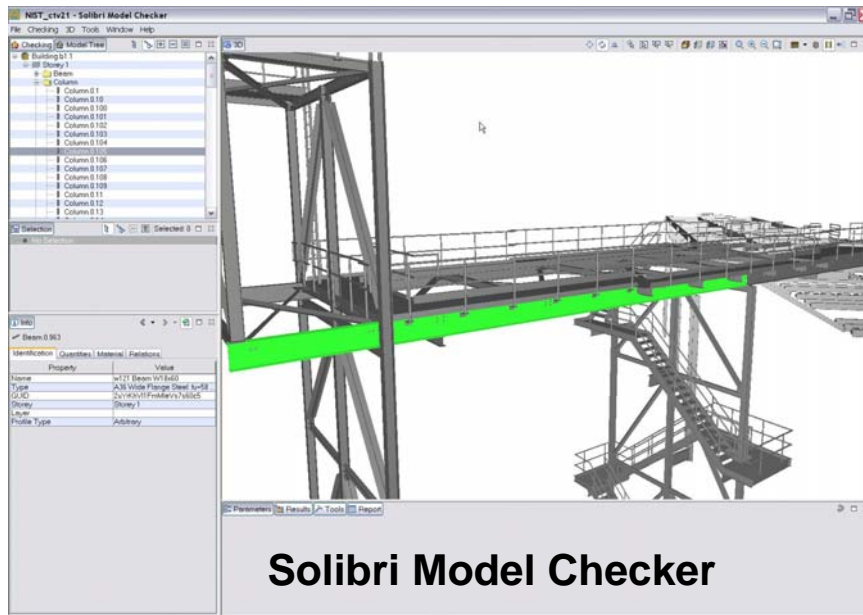**More IFC options**

< analysis model

< assemblies

< bolts

NIST Large Fire Research Facility Emissions Control System (ECS)

•**Fire tests in building (right)**

•**Steel structure carries ducts to ECS (left)**

•**Steel detailed in SDS/2 and exported to CIS/2**

DDS IFC Viewer

Solibri Model Checker

IFC Storey View

IFC Engine Viewer

IFC file import

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Architectural Desktop

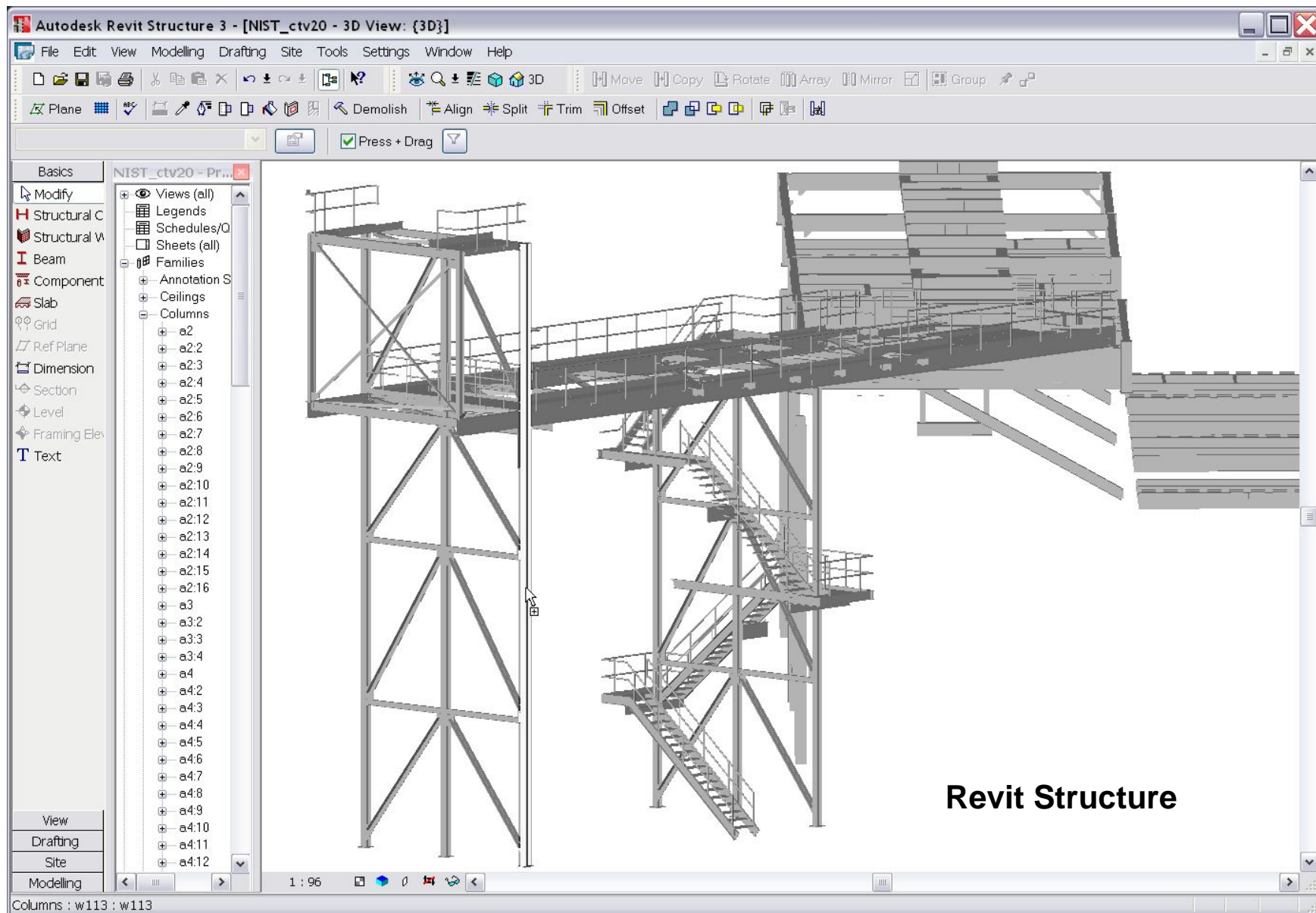**Bentley Architecture**

ArchiCAD

Octaga Modeller

IFC file import

Revit Structure

CIS/2 and IFC Certification

- **Is there a certification process for software products that implement CIS/2?**

- **When you hear that a software product has "IFC Certification", what does that mean?**

CIS/2 and IFC Certification

- **Is there a certification process for software products that implement CIS/2?**

- No. Does there need to be one? Currently informal testing

- **When you hear that a software product has "IFC Certification", what does that mean?**

- The resulting model exchanged via IFC is as you expected it to be, i.e. 100% of the model (geometry and attributes) can be exchanged via IFC 100% of the time

IFC Certification

- Certification only for the extended coordination view

- Vendors supply test IFC files
- Two types of test files:
  - Step 1 – many individual concepts: beam, wall, floor, space, cutouts, geometric representation, some combinations (door in a wall)
  - Step 2 – 2 or 3 complete projects

- Certification workshops (every 3-4 months), lots of work in between

- Every vendors tries to import the IFC files
- Results of the import tests are collected in spreadsheets
- Implementers agreements

- Issues must be resolved before Step 1 or Step 2 certification can be granted

IFC Certification Questions

- What is really tested with IFC Certification?

- Step 1 IFC test files
  - Coverage of concepts?
  - What set of files is sufficient for testing?

- Step 2 IFC test files
  - Representative of your real projects?
  - What concepts are tested?
  - How are they evaluated?

- How were the models modeled that generated the IFC files?

- Is 100% of the information transferred and accessible?

- Is the imported model true objects or just geometry?

Precast Concrete

- Compared 2D vs. 3D modeling
  - Documented workflows
  - Evaluated labor hours

- Architectural precast façade interoperability
  - Is the model representative?
  - How is it modeled?

- Modeled in several different CAD packages
  - Exported as IFC
  - IFC files evaluated
  - After IFC imported, resulting CAD model evaluated

Precast Concrete
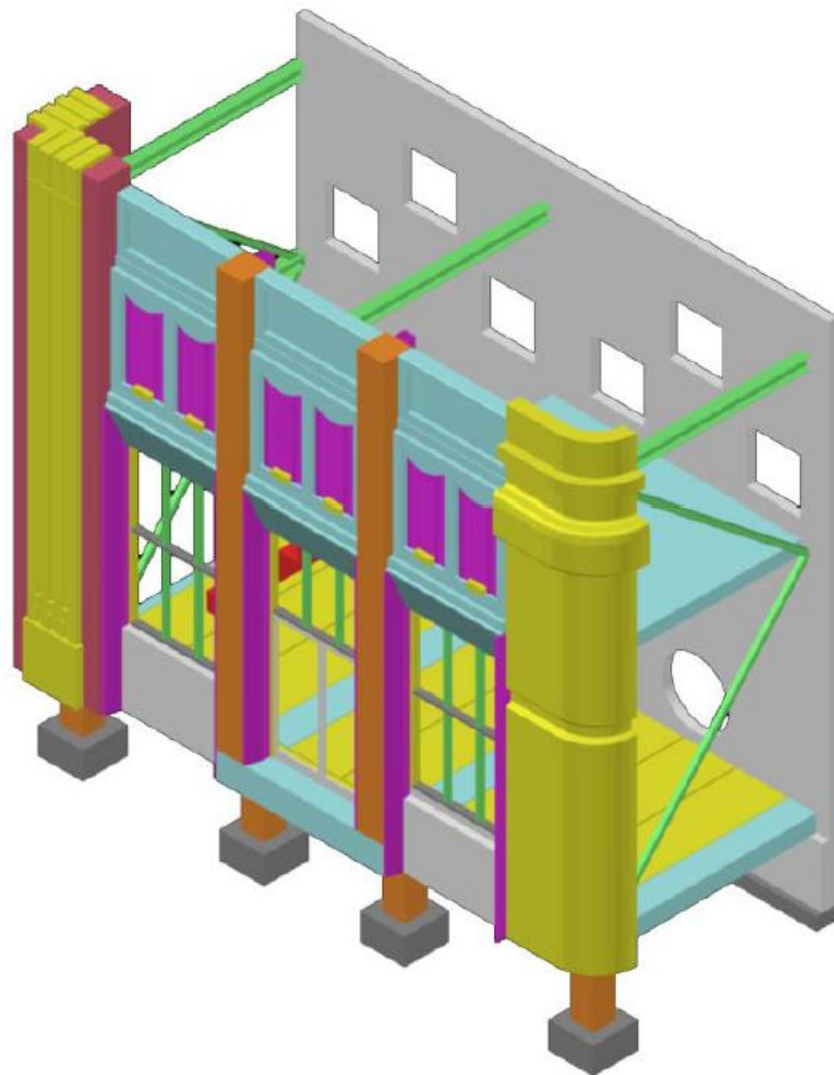
Test Model

Precast Concrete

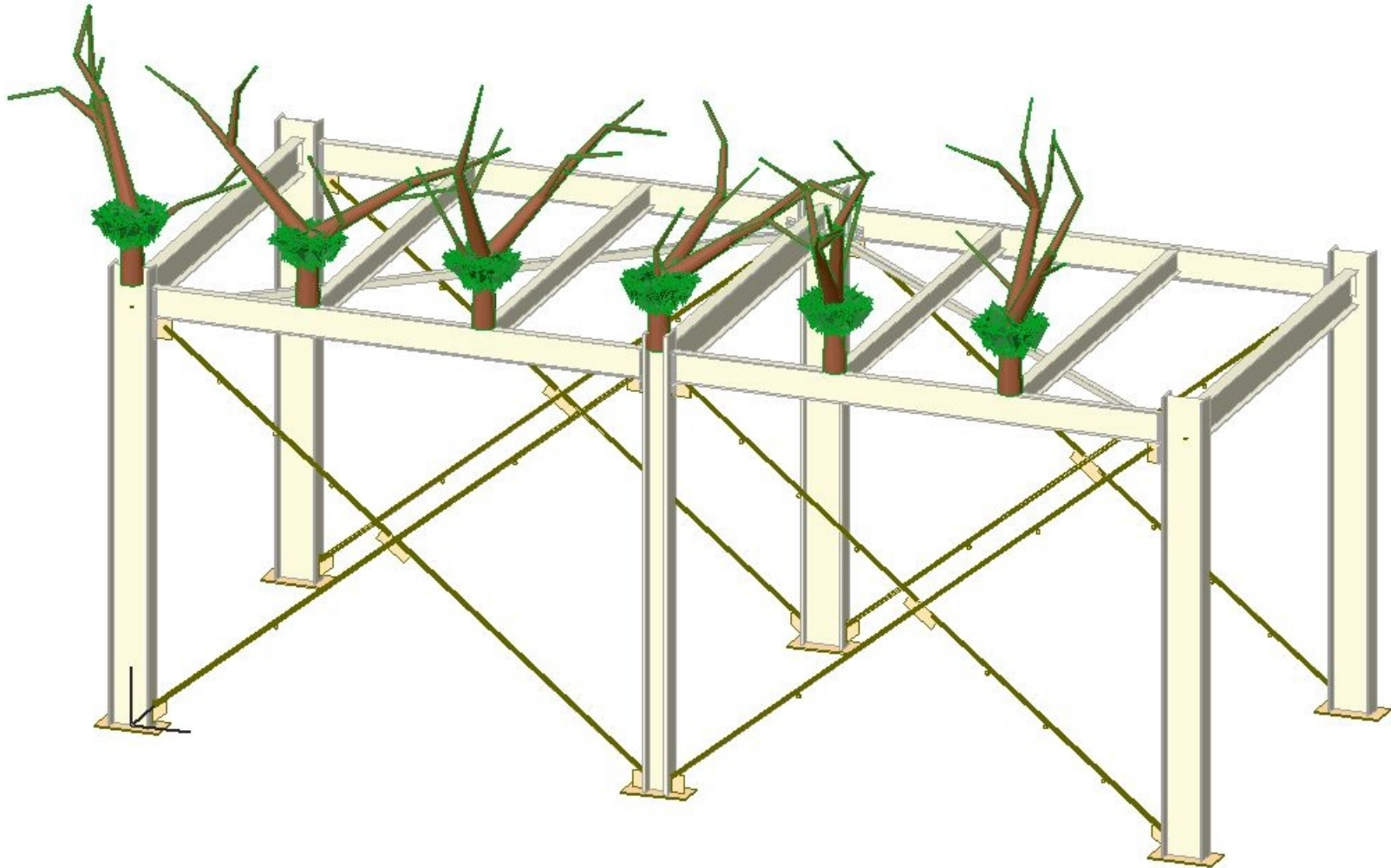| Building Element	ArchiCAD	Bentley Architecture	Digital Project	Revit Building
IfcBeam	16	9	29	18
IfcBuildingElementProxy	19	26	15	13
IfcColumn	31	4	15	5
IfcCurtainWall	-	42	-	4
IfcDoor	1	1	-	2
IfcFooting	-	15	-	-
IfcMember	-	-	-	52
IfcPlate	-	-	-	17
IfcSlab	8	9	1	10
IfcStair	1	1	-	1
IfcWall	18	3	1	9
IfcWindow	2	-	-	-
Total	96	110	61	131

NIST Research

- Develop methods and metrics for conformance and interoperability testing
- Establish a reliable and repeatable process that can be applied to product data models and their software implementations
- Move from "does it look right" to a more rigorous and measurement science approach for certification

- Methods to generate test models
- Develop testing methods
- Coverage of test files
- Conformance of software implementations

- Evaluation of current test methods and test files
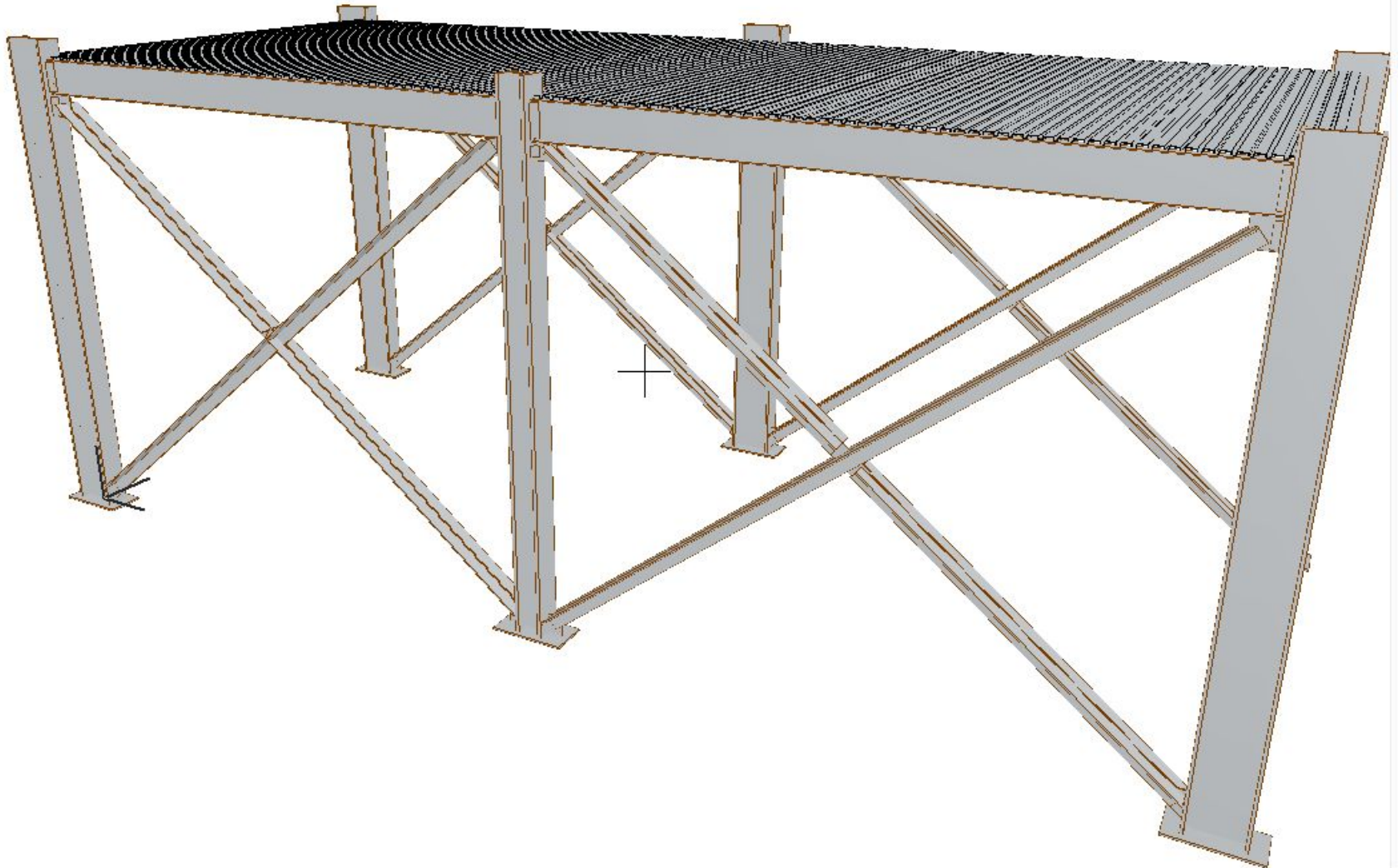- Tool to evaluate the coverage of test files

BIM and Interoperability

- A Building Information Model (BIM) is a **digital representation** of physical and functional characteristics of a facility. As such it serves as a **shared knowledge resource for information** about a facility forming a reliable basis for decisions during its life-cycle from inception onward.

- A basic premise of BIM is **collaboration by different stakeholders** at different phases of the life cycle of a facility to **insert, extract, update or modify information** in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on **open standards for interoperability**.

- Interoperability is necessary for BIM
- Software is tool used for BIM
- BIM is not necessarily software
- BIM is not necessarily one model of everything

- **Bad IFC file import**
- **Subsequent version - trees became chairs**
- **Current version – OK**

Corrugated decking is correct